# Ambient Air Particles: Their Toxic Components, Sources, and Health Impacts

Morton Lippmann
New York University School of Medicine

2004 PM Center Directors' Meeting
Washington, DC
September 27-28, 2004

*EPA Particulate Matter Research Centers Program*

# ISSUES TO BE DISCUSSED:

- Background Knowledge in 1997
- Sources of Ambient Air Particles
- Biological Responses to Inhaled Particles
- Applications of Source Apportionment to Health Effect Studies
- Identifying PM Components that may be Responsible for Health Impacts - Key Questions for Future Research

# BACKGROUND KNOWLEDGE IN 1997:

- Excess mortality is more closely associated with $PM_{2.5}$ and sulfate than with $PM_{10}$, TSP, Black Smoke, or routinely monitored pollutants gases.
- Particles between 2.5 and 10 µm have greater deposition in the tracheobronchial airways, while $PM_{2.5}$ has greatest deposition in distal gas-exchange airways.
- Most of the ambient air $PM_{2.5}$ mass is secondary aerosol, is relatively uniformly distributed over large geographic regions, and penetrates indoors with relatively little attenuation in concentration.

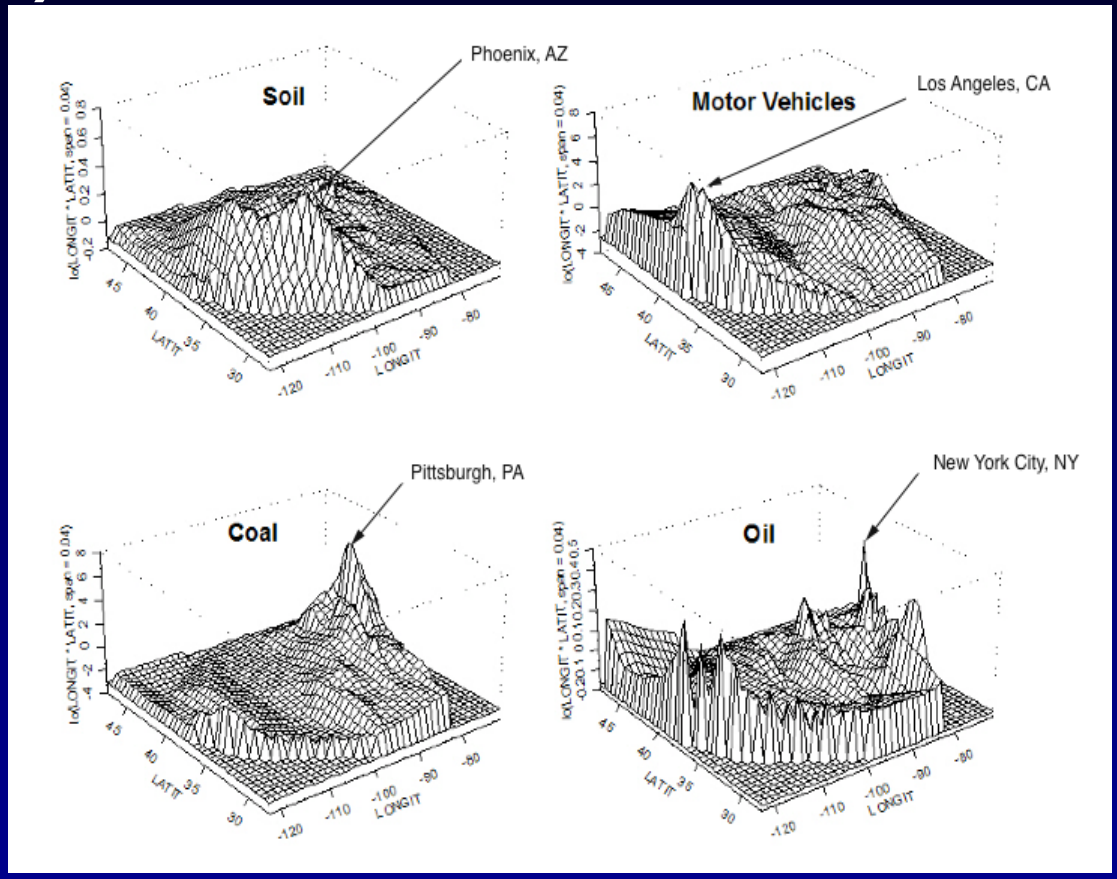
# BACKGROUND KNOWLEDGE IN 1997: (continued)

- Particles greater than 2.5 µm or less than 0.1 µm (ultrafine) have shorter atmospheric residence times and penetrate poorly into indoor air.
- Suspect PM components, based on limited and/or indirect information, included: strong acid, transition metals, PAHs, peroxides, elemental and organic carbon, and biological aerosols.

# SOURCES OF AMBIENT AIR PARTICLES

- **Primary**
  - Windblown soil particles
  - Construction and demolition debris
  - Fly ash from fossil fuel combustion
  - Mining and smelting
- **Secondary**
  - Atmospheric conversion of $SO_2$ and $NO_x$ to sulfates and nitrates
  - Photochemical reactions of $NO_2$ and hydrocarbons to form organic fine particles
  - Condensation of semi-volatile effluents (sulfuric acid and metals from hot processes, and organics from vegetation and biological decay)

# SOURCES OF AMBIENT AIR PARTICLES
## (continued)




U.S. Maps of Latitude-Longitude Smooths of 2000-2003 Speciation Network Source Factor Scores Showing the Geographic Distribution of Source Impacts, and Confirming Factor Interpretations (Lall and Thurston).

# SOURCES OF AMBIENT AIR PARTICLES (continued)

$PM_{2.5}$ Exposures in Seattle, WA ($mg/m^3$) *

| *Source/Feature* | *Outdoor* | *Indoor* | *Personal* |
|---|---|---|---|
| Vegetative Burning | 8.7 | 5.4 | 3.4 |
| Mobile | 1.1 | 0.4 | 0.6 |
| Secondary Sulfate | 2.2 | 1.3 | 1.6 |
| Crustal | 0.3 | 2.3 | 2.7 |

* Fall, Winter and Spring data

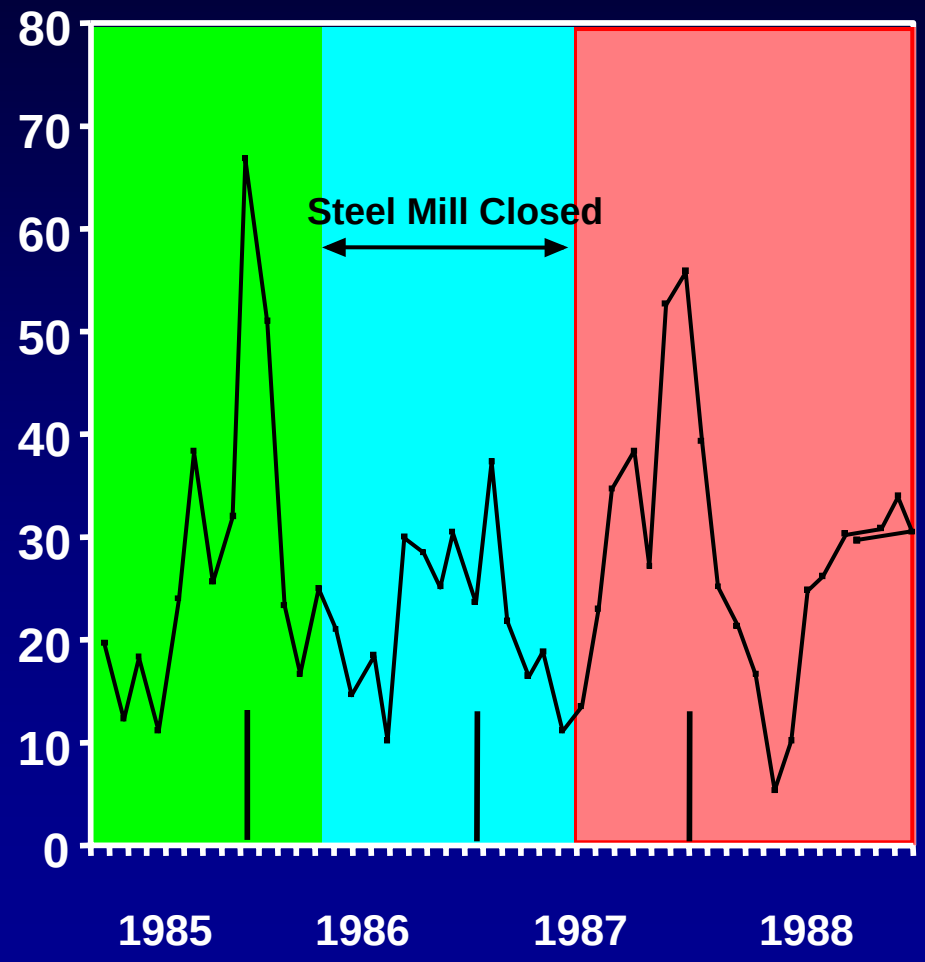
Larson, et al., *JAMA*, 2004

# BIOLOGICAL RESPONSES TO INHALED PARTICLES:

- Pulmonary
- Cardiovascular
- Developmental
- Nervous System
- Immunological
- Cancer

# HEALTH IMPACTS

## Monthly Bronchitis and Asthma Admissions in Utah Valley: All Ages




*EPA Particulate Matter Research Centers Program*

# HEALTH IMPACTS (continued)

## Recent Study of Utah Valley Dust (UVD)

## Conclusions

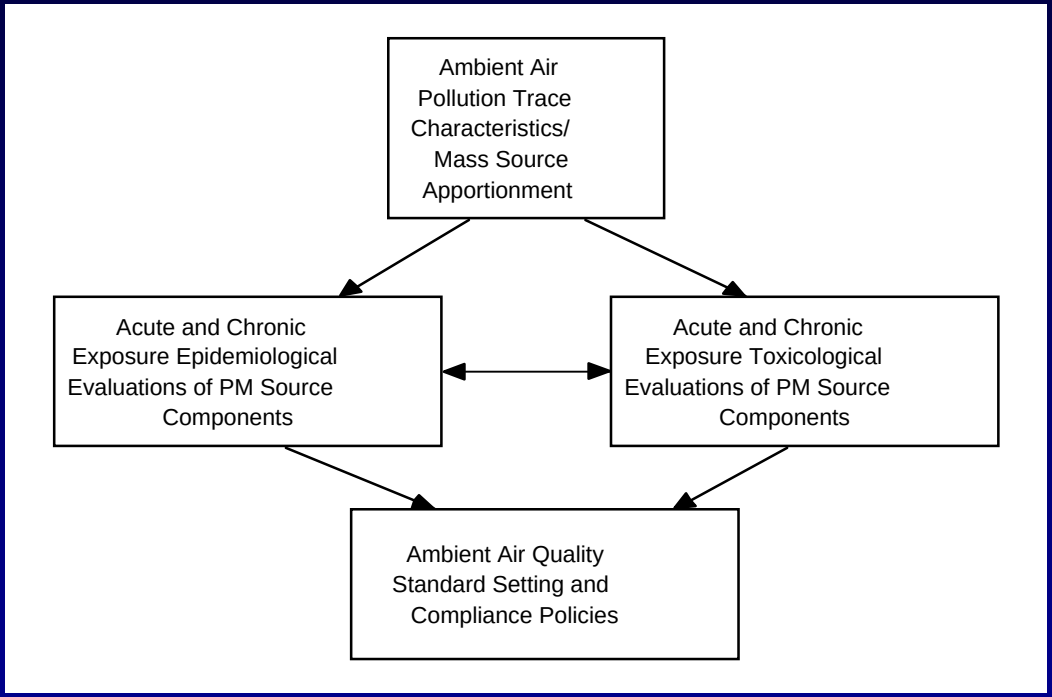
- UVD instillation into human or animal lungs results in a marked inflammatory response, compared with saline instillation.
- UVD from Yrs 1 & 3 caused increased inflammation compared with UVD from Yr 2.
- The difference between Yrs 1 & 3 and Yr 2 might be explained by differences in transition metal content (perhaps Cu and Zn).
- The Yrs 1 & 3 versus Yr 2 pattern observed in vivo can also be replicated with cultured human epithelial cells.
- UVD activates the EGF receptor signaling pathway, which may contribute to the cellular responses that underlie health effects of PM inhalation in the Utah Valley.

# PM Source Apportionment and Health Effects

## Background

- Recent epidemiological and toxicological research suggests that PM health effects can vary by source category.
- However, there are a variety of source apportionment methods now used to assess PM impacts.
- While source apportionment methods have been employed for epidemiology, the effect of variations in source apportionment approach on subsequent PM health effects evaluation is not known.

# Application of Source Apportionment to Health Effects Studies



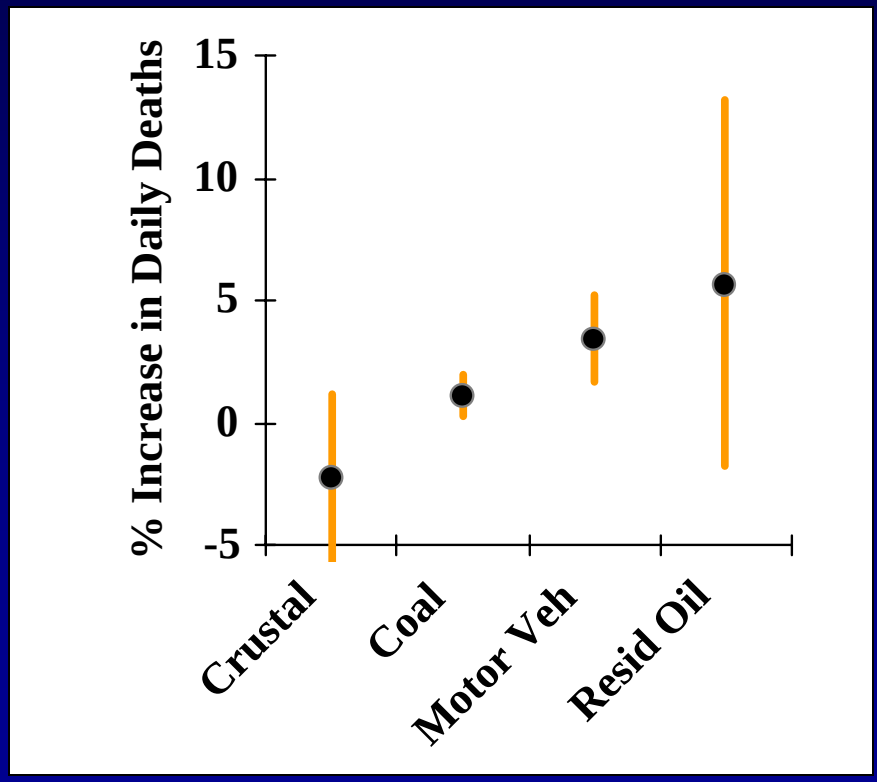

Integrated PM Center Approach for Assessing the Relative Roles of PM Components in PM Mass Health Associations (Thurston, 2001).

*EPA Particulate Matter Research Centers Program*

# Application of Source Apportionment to Health Effects Studies (continued)

Source-Specific $PM_{2.5}$ and Daily Mortality in Six US Cities
*Laden, Neas, Dockery, Schwartz, EHP 2000*

- $PM_{2.5}$ associated with daily mortality in six cities (1980's)
- Factor analysis of elemental composition of $PM_{2.5}$ used to estimate source-specific concentrations
- Associations estimated with 4 source classes (10 mg/m$^3$)
  - Crustal (Si)
  - Motor Vehicle (Pb)
  - Coal (Se)
  - Residual Oil (Vn, Mn)

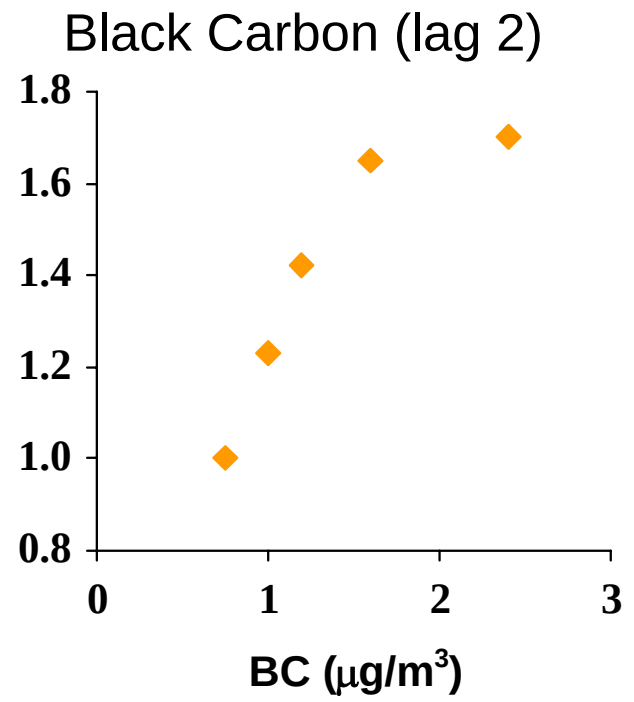



*EPA Particulate Matter Research Centers Program*

# Application of Source Apportionment to Health Effects Studies (continued)

Air Pollution and Incidence of Cardiac Arrhythmias
*Peters et al., Epidemiology 2000*

- OR for ICD Discharge associated with $PM_{2.5}$, Black Carbon, and $NO_2$
- Stronger associations among 6 patients with 10+ events (effect of 5%-95% air pollution)
  - $PM_{2.5}$ 1.22 (0.7,2.0)
  - BC 2.16 (1.0,4.9)
  - $NO_2$ 3.13 (1.8,5.6)



# EPA-PM Centers
# Workshop on PM Source Apportionment and Health Effects
# May 28-30, 2003

## Arden House Conference Center

Program Chair:  George D. Thurston, Sc.D., NYU School of Medicine

*EPA Particulate Matter Research Centers Program*

**EPA-PM Centers**
**Workshop on PM Source Apportionment and Health Effects**

# Workshop Goals

- To bring together key researchers from the various PM Centers and elsewhere to characterize the present status of PM Source Apportionment-Health Effects Assessment;
- To inter-compare variations in results of separate research teams' independent analyses of reference PM databases;
- Using the research teams' respective PM source apportionments to evaluate the variation in the associated source-specific effects estimated using a single standardized health effects model of mortality;
- To identify key research needs for Source Apportionment Health Effects Evaluation.

**EPA-PM Centers**
**Workshop on PM Source Apportionment and Health Effects**

# Participating Research Groups

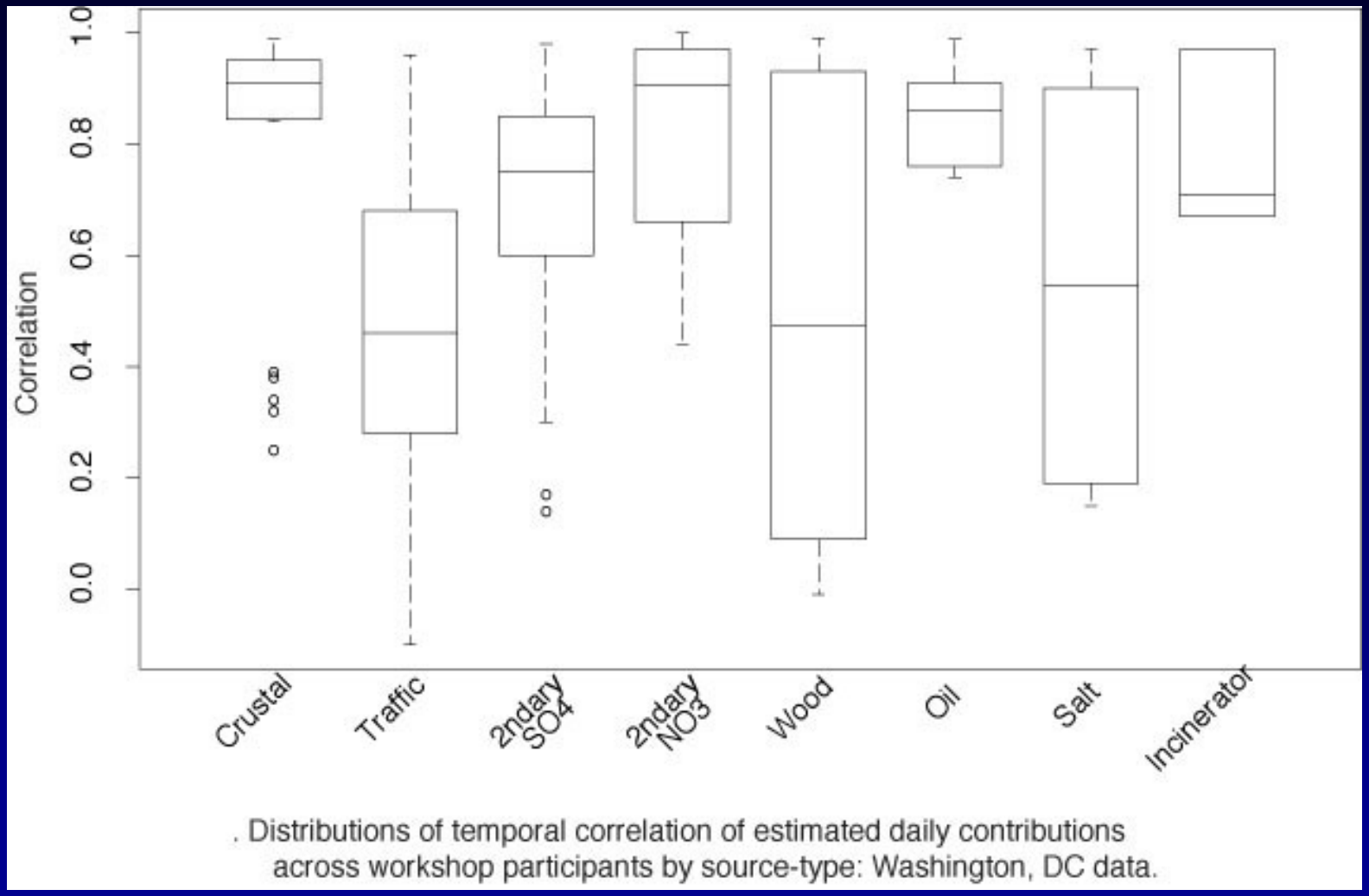
- Brigham Young University: Provo, UT
- Clarkson University: Potsdam, NY
- GSF Research-Univ. of Rochester: Nuremberg, GE-Rochester, NY
- Harvard University School of Public Health: Boston,MA
- New York University School of Medicine: Tuxedo, NY
- University of Southern California: Los Angeles, CA
- University of Washington: Seattle, WA
- U.S. Environmental Protection Agency: RTP, NC

**EPA-PM Centers**
**Workshop on PM Source Apportionment and Health Effects**

# Attendees

*EPA Particulate Matter Research Centers Program*

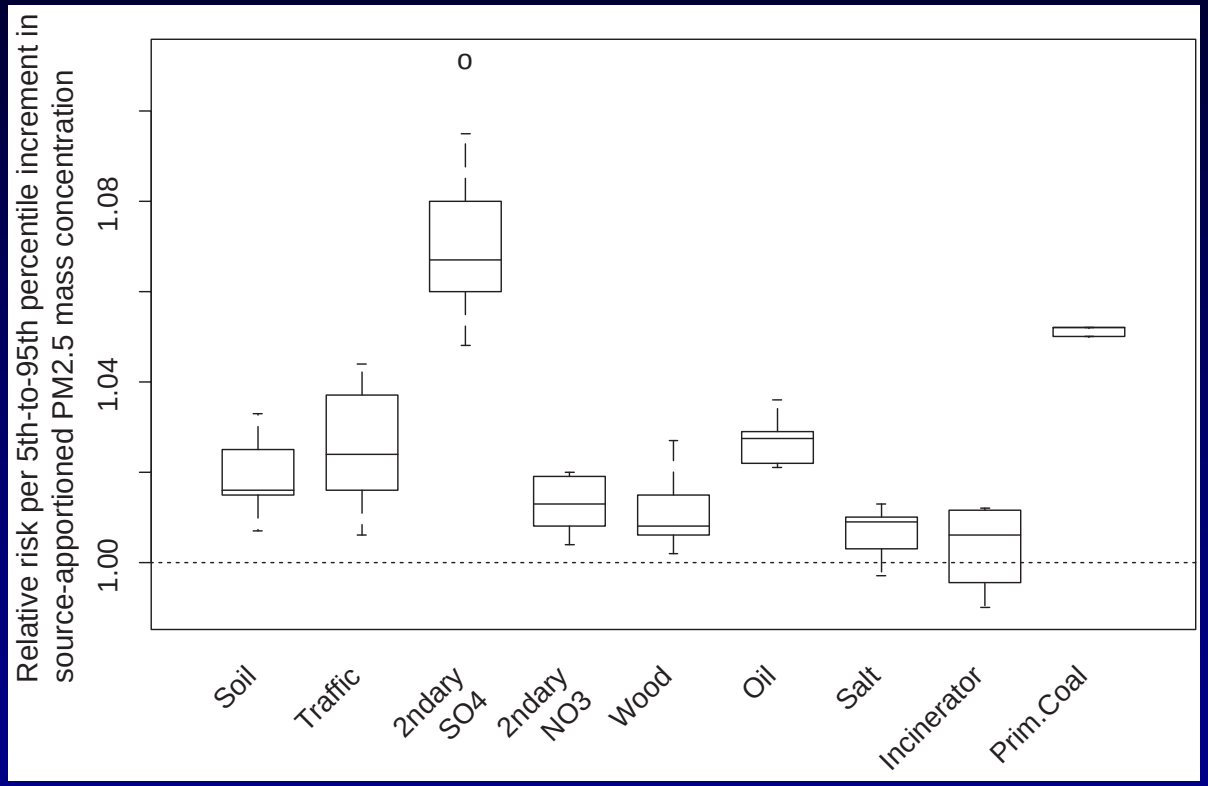
# EPA-PM Centers
# Workshop on PM Source Apportionment and Health Effects




. Distributions of temporal correlation of estimated daily contributions across workshop participants by source-type: Washington, DC data.

*EPA Particulate Matter Research Centers Program*

# EPA-PM Centers
# Workshop on PM Source Apportionment and Health Effects




Distribution of $PM_{2.5}$ mortality relative risk point estimates across research groups/methods by source type for the Washington, DC data analyzed by eight research teams. Note: there were only three estimates for “primary coal”.

*EPA Particulate Matter Research Centers Program*

# Identifying PM Components that may be Responsible for Health Impacts

## Key Questions for Future Research

1. Which are the most toxic components of ambient air PM (and their sources)? This is important because:
   a. Identification permits more focused studies on mechanisms of response.
   b. Controls of sources can become more efficient.
   c. Air quality monitoring could better track progress of Public Health protective measures.

# Identifying PM Components that may be Responsible for Health Impacts

## Key Questions for Future Research

2. What is the extent of the multiple health impacts of PM exposures, and which components most influence their observed excesses? This is important for each of the following categories:
   a. Cardiovascular Mortality, which has the greatest public health and economic impact.
   b. Lung Cancer, which remains a major concern.
   c. Pneumonia Mortality, which is in excess on peak pollution days.
   d. Chronic Obstructive Pulmonary Disease, which is highly debilitating.
   e. Asthma Exacerbation, which is a growing problem in children.
   f. Fetal and Childhood Development, which is an emerging area of concern.